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ABSTRACT

This report presents a framework for considering general and work-related adult cognitive performance that is drawn from current theory and research on life-span developmental and cognitive psychology. The first section considers the concept of basic skills and the classical distinction between achievement and aptitude. By drawing linkages between these concepts, the second section presents both a model and a set of propositions dealing with the aging of intellectual functioning. The model shows that the effects of age on intellectual skills and abilities is neither uniformly positive nor negative. In the third section, specific research that has attempted to link intellectual ability and basic academic skills to job performance (with only modest success) is reviewed. The fourth section considers another set of intellectual competencies: domain-specific knowledge bases. The report suggests that the acquisition and updating of job-specific knowledge holds the most promise for the aging of work-related abilities. The final section suggests that job competence should include, and go beyond, basic skills. It argues that an understanding of job competence must not only encompass the concepts of intellectual aptitude and basic skills but also include concepts of individual expertise in job-related domains, interpersonal and everyday skills, and personal motivation. Contains 191 references. (YLB)

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NATIONAL CENTER ON ADULT LITERACY

ABILITIES AND COMPETENCIES IN ADULTHOOD:

LIFE-SPAN PERSPECTIVES ON WORKPLACE SKILLS

Jacqui Smith
Michael Marsiske
Max Planck Institute for Human Development and Education

OECD/NCAL TECHNICAL REPORT TR94-12
OCTOBER 1994

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ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

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TABLE OF CONTENTS

Acknowledgments	*i*
Table of Contents	*iii*
Abstract	*v*
Introduction	1
Is It Useful to Distinguish Between Intelligence and Basic Skills?	2
A Life-Span Approach to Cognitive and Intellectual Functioning in Adulthood	4
The Mechanics and Pragmatics at Work	12
Conclusions: Basic Skills, Intelligence, and Workplace Performance	20
References	*25*
Appendix	*A-i*

ABILITIES AND COMPETENCIES IN ADULTHOOD:

LIFE-SPAN PERSPECTIVES ON WORKPLACE SKILLS

Jacqui Smith
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Abstract

This report presents a framework for considering general and work-related adult cognitive performance that is drawn from current theory and research on life-span developmental and cognitive psychology. Two categories of functioning are distinguished, one primarily reflecting the so-called "mechanics" of the cognitive system (e.g., processing speed, reasoning, working memory capacity) and the other related more to the "pragmatics" (i.e., the application of knowledge acquired through acculturation, education, and training). A central goal of the report is to embed literacy-based definitions of basic skills within this broader framework, and to point out assessment, adult education, and policy implications. It is suggested that different job-related tasks and contexts require different competencies associated with the mechanics and pragmatics of intelligence, and that their dynamics and interactions need to be considered across the adult working career. To illustrate this perspective, research dealing with lifelong learning (especially the processes of maintaining and updating skills and domain-specific expertise) and age-related constraints on performance is reviewed.

INTRODUCTION

Work and work-related activities comprise the largest proportion of the human life-span. Most adults can expect to spend 40 or more years in the work force. This part of the life span is associated with major cognitive and intellectual changes. A natural question, therefore, emerges: Should normal age-related changes in intellectual functioning be expected to exert an influence on the work-related performance of adults? As this report will show, research in basic and applied psychology has much to offer researchers concerned with adult literacy and education. The fact that there is typically little contact between these areas can be attributed to subgroup specialization in topics and to the difficulties that the research community often seems to have in communicating relevant findings to policymakers and practitioners. This report represents our attempt to bridge some of these disciplinary gaps.

What does a life-span developmental perspective have to offer? First and foremost, it draws attention to the dimensions of time and context. This report sketches a set of theoretical perspectives drawn from life-span developmental psychology (e.g., Baltes, 1987) that bear on the issues of the aging of mental abilities and their everyday consequences. These issues are seen as fundamental to understanding constructs like literacy in adulthood. The general position is that, across adulthood, both intellectual gains and losses are to be expected (e.g., Baltes, 1991, 1993) and that changes have implications for the kinds of work in which people engage over adulthood. Workplaces can maximize the benefits obtained from employees of different ages by providing *age-friendly environments*; that is, environments that support the use, maintenance, and updating of competencies in different groups. An implication of this position is that abilities and skills in adulthood, and their relationship to work productivity and performance, are understood as *moving targets*; the predictors of work performance may themselves change over adulthood, from criteria associated with the basic mechanics of intellectual functioning (e.g., attention, speed) to criteria that are more knowledge-related and linked to the pragmatics of intelligence.

This report is organized into five main sections. First, the concept of basic skills is considered, as is the classical distinction between achievement and aptitude. Second, by drawing linkages between these concepts, both a model and a set of propositions dealing with the aging of intellectual functioning are presented. The model shows that the effects of age on intellectual skills and abilities is neither uniformly positive nor negative. In the third section, specific research that has attempted to link intellectual ability and basic academic skills to job performance (with only modest success) is reviewed. Fourth, another set of intellectual competencies is considered, namely domain-specific knowledge bases, which are often ignored by traditional measures of intelligence and basic skills, but which may be very relevant for understanding individual differences in job performance. This report suggests that it is the acquisition and updating of job-specific knowledge that holds the most promise for the aging of work-related abilities. Finally, it is suggested that job competence should include, but go beyond, basic skills. It is argued that an understanding of job competence

must not only encompass the concepts of intellectual aptitude and basic skills, but it must also include concepts of individual expertise in job-related domains, interpersonal and everyday skills, and personal motivation.

Is It Useful to Distinguish Between Intelligence and Basic Skills?

The basic skills label has been used for at least two decades, in an attempt to broaden the conceptual focus about aspects of cognitive and intellectual capacity relevant to the workplace beyond simple *literacy* (the ability to process and comprehend printed materials) and *academic achievement* (i.e., the end-product of education; the knowledge and skills acquired through the process of formal schooling). The basic skills or minimum competency concept has also achieved substantial political currency in the United States since the 1970s, because most states have mandated its assessment in students (e.g., Haney & Madaus, 1978). As Reynolds and Bezruckzo (1989) noted, this has proven to be problematic since there is little theoretical consensus on what to measure, or how to measure it. For many investigators, basic skills do not differ from standardized achievement skills, or the academic competencies associated with literacy and numeracy (e.g., Hieronymus, Lindquist, & Hoover, 1980). For others, basic skills are more synonymous with life skills or the kinds of abilities needed for the solution of everyday problems (e.g., Educational Testing Service, 1977; Reynolds & Bezruczko, 1989; Willis & Schaie, 1986a).

Beyond these conceptual issues, the measurement of achievement is also premised on the questionable distinction between aptitude (potential or ability) and achievement. As Stanovich (1991) has noted, the ability/literacy distinction is based on the outmoded idea that ability is unlearned potential, while literacy and other achievement indices measure learned knowledge and skills. Many scholars now recognize that traditional psychometric measures of intellectual ability are neither experience free nor culture fair (Cattell & Cattell, 1961; Helms, 1992) and that intellectual performance contains substantial proportions of both genetic and environmental variance (e.g., Cardon, Fulker, DeFries, & Plomin, 1992; Pedersen, Plomin, Nesselroade, & McClearn, 1992).

The empirical literature has generally not supported strong distinctions between intellectual abilities, academic achievement, and basic skills. In school children and adults, measures of psychometric intellectual ability have tended to correlate with basic skills measures at levels between .50 and .90 (e.g., Haddad & Juliano, 1991; Katz & Ben-Yochanan, 1990; Martin & Hoover, 1987; Schellinger & Beer, 1991; Willis, Jay, Diehl, & Marsiske, 1992; Willis & Schaie, 1986a).

The empirical distinction between basic skills (measuring such academic competencies as literacy and numeracy) and life skills has also been unclear.

Reynolds and Bezruczko (1987), for example, designed a measure of consumer life skills emphasizing such domains as finance, communication, health, occupation, and government. For each domain, over 2500 Chicago elementary students were presented with problems involving language comprehension, computation, and problem solving (e.g., whom to call in an emergency). Reynolds and Bezruczko found that language comprehension and problem solving were not factorially distinct. Furthermore, when performance on this life skills measure was correlated with subscales of the Iowa Test of Basic Skills, subscale correlations generally exceeded .50 or .60. In research with adults, numerous studies have also found that measures of basic intellectual abilities (reasoning, verbal knowledge, fluency, speed) have substantial salience (correlations between .20 and .90) for the prediction of many different measures of everyday problem solving (e.g., Camp, Doherty, Moody-Thomas, & Denney, 1989; Cornelius & Caspi, 1987; Hartley, 1989; Lindenberger, Mayr, & Kliegl, 1993; Willis, Marsiske, & Diehl, 1991).

In addition to the lack of an empirical distinction between measures of intelligence, life skills, and basic skills, the basic skills idea is conceptually problematic. In one view, a basic skill cannot be defined without reference to the context in which it is applied; a basic skill implies broad, domain-general skills that might be used by all individuals. In practice, the specific literacy and numeracy skills required by particular individuals will vary as a function of the setting in which they are employed (Hull, 1993; Ostenk, 1992; Resnick, 1990). Basic numeracy demands, for example, will be both qualitatively and quantitatively different for the physicist and the grocer.

The idea of the context specificity of competence is a central view in life-span developmental psychology (e.g., Baltes & Baltes, 1990; Lerner, 1984). Current research and theory on literacy and basic skills also increasingly embrace the need to assess basic skills in a context-appropriate way (e.g., Engstrom, 1992; Kazemek, 1988; Lave, 1988). Kirsch and his colleagues (e.g., Guthrie & Kirsch, 1988), for example, have attempted to alert literacy researchers to the notion that literacy is a relative construct. The literacy or basic skill demands on adults may vary with the personal, social, situational, and cultural contexts of individuals (e.g., Kirsch & Jungeblut, 1986; Resnick, 1990)—an idea that shares similarities with current perspectives on adult intellectual development (e.g., Baltes, 1993). Furthermore, as Kirsch and colleagues have also noted, showing that individuals have minimum competency in literacy domains does not address whether they can successfully deal with more complex challenge situations (see also Hannaway, 1992). Indeed, for some individuals, it may be more important to talk about their degree of expertise in the literacy domain than their basic competence (e.g., Scardamalia & Bereiter, 1991). Analytically, the question becomes how the general skills and abilities often studied in the adult education literature relate to the specific skills and abilities used in everyday lives.

For these reasons, it is argued that human abilities are best conceptualized as both a set of broad, domain-general, cognitive and intellectual abilities and a set of domain-specific, knowledge and skill bases. These include, but go beyond, the kinds of literacy and numeracy skills typically discussed in the basic skills literature. The separate and joint operation of these two sets of abilities must be considered to provide an adequate description of the context-specific competencies of adult workers. The hope is that in presenting these perspectives

from adult developmental psychology, the kinds of questions that large-scale studies of adult literacy, as currently measured, can and cannot answer will be more clearly explained.

A Life-Span Approach to Cognitive and Intellectual Functioning in Adulthood

Research on the patterns and processes underlying changes in intellectual functioning throughout adulthood and into old age (especially psychometric definitions of intelligence) has been a topic of substantial scholarly interest for much of the twentieth century. There are a number of excellent reviews of the major findings (e.g., Baltes, 1993; Hoyer & Rybash, 1994; Lindenberger & Baltes, in press; Salthouse, 1991; Schaie, 1983, in press; Woodruff-Pak, 1989). The life-span approach, as defined by Baltes (1987), consists of a family of perspectives that attempt to describe the patterning of stability and change in behavior throughout the entire life course. The emphasis is on understanding the general principles of development (at all ages), and also on understanding both the range of interindividual differences in, and the intraindividual modifiability of, development. Thus, with regard to intellectual and cognitive development, the life-span approach seeks to understand the developmental course of specific intellectual abilities, but also to understand why some individuals' cognitive and intellectual functioning develops differently from others. In addition, life-span researchers are interested in the extent to which cognitive performance can be changed or enhanced at different points in the life course.

With regard to basic skills, the life-span approach has several implications. First, it suggests that levels of basic skill may change over the course of adulthood. A static conception of an individual's skill levels may not be adequate. Second, it suggests that the set of skills to be considered basic might vary across individuals.

Within life-span psychology, there are actually two broad sets of views on this latter issue, which are compatible with one another. One view argues that it is possible to talk about one broad, universal set of abilities; the performance of everyday tasks represents an investment of these abilities. Different tasks may require different admixtures of basic abilities. Implicit in this view is a kind of additive, multiple regression type of thinking, where basic abilities are thought to predict everyday competencies (e.g., Berry & Irvine, 1986; Cattell, 1988; Marsiske & Willis, in press; Willis & Schaie, 1986a). A second view focuses on both the basic skills that are invested and the consequences of that investment or specialization. In this view, specialization into task domains leads to the creation of new domain-specific bases of procedural and declarative knowledge. These new knowledge bases constitute an additional, emergent class of basic skills associated with the pragmatics of intelligence. Such new knowledge and skill domains can also be considered as basic because they are necessary for the effective

performance of specialized tasks. At the same time, basic does not connote universal in this use because the particular set of context-relevant knowledge and skills will vary across individuals (e.g., Baltes, 1993; Berg & Sternberg, 1985; Labouvie-Vief, 1985; Lerner, 1984; Smith & Baltes, 1990). This report draws most heavily on the second view.

A major feature of the life-span perspective, then, is that changes (and lack of change) are viewed as being embedded in the life context (biological, sociocultural, historical, and idiosyncratic) of the person. Although the origins of the view of intelligence as involving two categories of functioning (i.e., fluid vs. crystallized or mechanics vs. pragmatics; cf. Cattell, 1988) are psychometric, a number of researchers are attempting to identify the cognitive processes by which these two broad classes of functioning come to be dissociated (e.g., Lohman & Sheurman, 1992; Rabbitt, 1993; Salthouse, 1991; Sternberg, 1985). Beyond this, several major questions drive life-span research in intellectual functioning:

- What is the relationship of later levels of performance to earlier levels?
- Do individual differences increase with age, as adults experience increasingly varied personal and occupational life paths?
- What constraints on performance are set by the biological status of the individual (e.g., myelinization in childhood, age-associated physiological changes in late life)?
- Is adult intelligence best assessed with domain-general or context-specific tests, and does the content of such tests need to change with the age of individuals tested?
- How do the contexts in which individuals find themselves influence the nature and level of intellectual functioning?
- Do all intellectual and cognitive abilities develop in the same way?
- Are change and growth equally possible at all points in the life-span?

THE DYNAMICS OF GROWTH AND DECLINE

Before presenting some specific propositions meant to summarize the major findings regarding intellectual functioning during adulthood and into old age, a framework for considering developmental changes in adulthood that has substantial usefulness for organizing the literature needs to be described. Historically, theoretical and empirical writings concerning the changes in intellectual and cognitive performance in adulthood have highlighted two themes. First, as individuals age, some aspects of memory, reasoning, and problem solving show evidence of decline, especially in advanced old age (e.g., Baltes, 1993; Salthouse, 1991; Schaie, in press). Deficits in the speed of processing and the attentional capacity to manipulate complex mental stimuli have frequently been evoked as process explanations for these declines (e.g., Baddeley, 1992; Craik & Byrd, 1982; Hertzog, 1989; Kliegl, Mayr, & Krampe, in press; Lindenberger, Mayr, & Kliegl, 1993; Salthouse, 1991). The ultimate source of such age-related losses is generally assumed to be related to

changes in physical health and the central nervous system (e.g., Elias, Elias, Robbins, & Gage, 1987; Finch, 1990; Hertzog, Schaie, & Gribbin, 1978; Horn, 1982).

A second theme in research on the aging of intelligence has concerned the discovery of domains where aging is associated with stability and growth. Associated theory and research deal with (a) descriptions of expert performance in various occupations and disciplines (Ericsson & Smith, 1991; Featherman, Smith, & Peterson, 1990; Glaser, 1984; Hoyer, 1985); (b) distinctions between highly practiced and automated task domains and more novel, effort-demanding domains (e.g., Berg & Sternberg, 1985; Denney, 1984, 1989); (c) the influence of highly familiar and routinized everyday contexts (e.g., Labouvie-Vief, 1985; Sternberg & Wagner, 1986); and (d) the benefits of aging in terms of exposure to and appropriation of collective and shared social knowledge from the surrounding culture (Berger & Luckman, 1967; Cattell, 1971; Cole, 1990; Horn & Hofer, 1992).

The life-span approach to the study of intelligence has attempted to integrate these two themes. As Baltes (1987) has noted, life-long development always consists of the "joint occurrence of gain and loss." This idea is related to the notion of canalization (Waddington, 1975; Lerner, 1984), in that the selection of any particular developmental option may preclude the pursuit and optimization of other options. When a system has limited resources, investment in one domain of functioning comes at the cost of being able to invest in others. As individuals move through middle age and late adulthood, this dynamic takes on new meaning as the available pool of resources (e.g., biological, psychological, social, and economic) typically begins to shrink or becomes even more limited than before. Acceptance of some losses and selective resource investment in personally relevant domains may become increasingly important (e.g., Baltes & Baltes, 1990; Brandtstädter, Wentura, & Greve, 1993; Carstensen, 1993; Heckhausen & Schulz, 1993; Staudinger, Marsiske, & Baltes, 1993).

In the context of intellectual functioning, Figure 1 (see Appendix B) illustrates this gain/loss dynamic. This figure is drawn from the work of Baltes and his colleagues (e.g., Baltes, Dittmann-Kohli, & Dixon, 1984). This dual-process conception of intellectual development draws on earlier ideas proposed by Hebb (1949) and Cattell and Horn (e.g., Cattell, 1971; Horn & Hofer, 1992). It combines psychometric conceptions of the multifactorial structure of intelligence with cognitive and evolutionary psychological perspectives. In this scheme, cognitive mechanics are thought to reflect the neurophysiological functioning of the brain and central nervous system. The cognitive pragmatics, on the other hand, are thought to reflect knowledge that individuals acquire from their culture as they engage in social transactions within it.

The two different aspects of cognitive and intellectual functioning generally show different developmental trajectories, and the specific ages at which these trajectories diverge is in some dispute (e.g., Baltes & Schaie, 1976; Horn & Donaldson, 1976). Specifically, cognitive activities associated with the pragmatics of intelligence (e.g., Baltes & Smith, 1990; Dixon & Baltes, 1986) that primarily involve general background and/or domain-specific knowledge for performance are contrasted with a category of activities where performance is more a function of basic cognitive operations

and processes, or the mechanics of intelligence (Kliegl & Baltes, 1987). It is predicted that depending upon how representative a task is of one or the other of these forms of intelligence, that task will yield a pattern of growth, decline, or stability as individuals age. Typical literacy tasks represent a complex combination of these mechanics and pragmatics (Marsiske & Willis, in press; Willis & Marsiske, 1991).

Major Findings Regarding Intellectual Aging

The evidence for this dual-process conception of intellectual aging is now considered by summarizing the data into seven major propositions, which have been adapted from the life-span propositional framework used by Baltes and his colleagues (e.g., Baltes, 1987; Baltes, Dittmann-Kohli, & Dixon, 1984; Dixon & Baltes, 1986; Smith & Baltes, 1990; Staudinger, Cornelius, & Baltes, 1989). The first four propositions summarize general findings regarding the patterns of change that have been observed during adulthood and old age. The patterns of change are normative: They do not describe disease-related patterns of intellectual aging (but see Bäckman, 1992; Baltes, Kühl, & Sowarka, 1992; Camp & Schaller, 1989). The last three propositions embed developmental change patterns into the context of adult life. Together, these propositions encompass the key life-span concepts of (a) multidirectionality, (b) multidimensionality, (c) interindividual differences, and (c) intraindividual plasticity.

- *Proposition 1: The central feature of adult intelligence is one of stability in the average range.*

  Average here refers to the cognitive resources required in day-to-day functioning, rather than in extreme or special circumstances. Across the broad range of young adulthood and midlife, there is no reliable decline in intellectual and cognitive performance. Historically, however, this stability was not viewed as the dominant developmental trajectory of intellectual functioning (e.g., Lindenberger & Baltes, in press; Woodruff-Pak, 1989). Most early studies of intellectual aging were cross-sectional and involved comparisons of adults of different ages, comparisons which confounded maturational or ontogenetic change with generational variation between different age cohorts (Baltes, Reese, & Nesselroade, 1977; Labouvie-Vief, Hoyer, Baltes, & Baltes, 1974; Schaie, 1965). Most findings regarding the stability of average intellectual functioning have come from longitudinal (e.g., Cunningham & Owens, 1983; Schmitz-Scherzer & Thomae, 1983) and sequential (e.g., Schaie, in press) studies. Such studies follow the same individuals over time, so that developmental comparisons are made between the same individuals at different ages. These research approaches eliminate the confounding of cohort differences but contain other methodological problems, including selective subject attrition (Baltes, Schaie, & Nardi, 1971), the beneficial effects of multiple retestings (e.g., Baltes, Sowarka, & Kliegl, 1989; Hofland, Willis, & Baltes, 1981), and the influence of uncontrollable events occurring in the period between longitudinal testings (Schaie, 1965).

Longitudinal studies, which represent the best estimates available of true intraindividual change trajectories, provide the major support for Proposition 1. In one of the major studies, the Seattle Longitudinal Study, virtually all abilities examined evinced stability or slight increase until about age 53. With the exception of perceptual speed, all other abilities considered (inductive reasoning, spatial orientation, verbal ability, numeric ability, and verbal memory) showed relatively little age-related variation in midlife and reached an asymptote between 53 and 60. Modest, linear decline became normative thereafter (Schaie, in press). Even after normative declines have begun, the stability of individual differences generally exceeds 0.8; individuals with relatively high levels of predecline intellectual functioning typically remain higher than their age peers in advanced old age. It is important to note that these findings of the relative stability of intellectual functioning until the sixth and seventh decades of life are thought to apply to situations that pose low or intermediate levels of challenge; it is suggested below that high-challenge conditions may differ. Still, with regard to work contexts, the major implication of this psychometric literature is that employees may be expected to have fairly stable levels of both mechanical and pragmatic cognitive resources on which to draw throughout most or all of the work career.

- *Proposition 2: There may be instances of decline in some specific functions.*

  The optimistic view of stability in adults' intellectual functioning must be tempered with the acknowledgment that, in some specific functions, the period after age 60 is a time of normative decline. A large body of research on cognitive mechanics (most of it cross-sectional in nature) has been devoted to documenting declines in specific functions. Table 1 (see Appendix A) presents a selective overview of some major reviews in this area. As Table 1 shows, many of the processes in which decline has been reported refer not to knowledge-based processes, but to processes related to basic attentional, perceptual, memory, reasoning, and speeded functioning.

  There have been very few longitudinal investigations of intraindividual change in basic mechanics processes. In a variety of tasks (e.g., paired-associate learning, visual retention, working memory, processing time), several studies have reported, not unlike studies with psychometric intelligence measures, significant normative mean decline beginning in the 60s or 70s (e.g., Arenberg, 1982; Hultsch, Hertzog, Small, McDonald-Miszezak, & Dixon, 1992; McCarty, Siegler, & Logue, 1982).

  For workplace functioning, these data suggest that until about the seventh decade of life, declines in cognitive mechanics like memory, attention, and speed may be

modest. On the other hand, when intellectual losses occur, they are most likely to occur first in the mechanics of intelligence. Jobs emphasizing rapid response or divided attention may be those which are most sensitive to the aging of workers.

- *Proposition 3: Some individuals may show patterns of selective growth in adulthood and old age.*

  Congruent with the dual-process conception, age-related losses in the mechanics of intelligence may occur concurrently with age-related stability or growth in the pragmatics of intelligence. This is not to imply a causal dynamic: It is not being proposed that losses in the mechanics lead to gains in the pragmatics. Rather, the experiential benefits accrued from living longer, practicing particular performances more, and having encountered a broader range of situations and conditions are hypothesized to have positive consequences for intellectual functioning.

  The major original evidence regarding age-related maintenance of knowledge-based functioning comes from studies of psychometric intelligence that included measures of world knowledge, practical knowledge, and verbal knowledge (e.g., Demming & Pressey, 1957; Horn & Cattell, 1966; Schaie, in press). In their original work on fluid and crystallized intelligence, for example, Horn and Cattell reported that there were significant negative cross-sectional age gradients for reasoning-based fluid intelligence measures beginning with the third decade of life, but that verbal and social knowledge-based crystallized intelligence measures did not show significant negative cross-sectional effects until at least the seventh decade of life. Despite elaboration of the fluid/crystallized model, this pattern of findings has remained robust (e.g., Horn & Hofer, 1992).

  Another area in which age-related preservation of knowledge-based functioning has been reported comes from the study of expert systems, a topic that will be discussed in greater detail below. The study of expertise has long focused on the acquisition and use of knowledge (Chi, Feltovich, & Glaser, 1981; Glaser, Lesjold, & Lajoie, 1985), and on different kinds of knowledge (e.g., procedural, declarative, structural) that individuals have (Anderson, 1982; Jonassen, Beissner, & Yacci, 1993). To date, little attention has been paid to the psychometric properties of domain-specific knowledge and skill assessments, although there has been a growth in attempts to improve measurement (e.g., Royer, Cisero, & Carlo, 1993). More recent work has begun to emphasize the potential compensatory uses of expert knowledge systems (cf. Ericsson & Smith, 1991; Salthouse, 1991). In studies of diverse expert groups, including chess and bridge players (Charness, 1985; Wagner & Scurrah, 1971), typists (Salthouse, 1984), clinical psychologists (Smith, Staudinger, & Baltes, in press) and pianists (e.g., Ericsson, Krampe, & Tesch-Römer, 1993; Krampe, 1994), results have suggested

that older experts can generally demonstrate levels of domain-relevant performance proficiency equal to, or greater than, that of younger experts. Although the evidence suggests that older experts encounter the same age-related losses in the mechanics of cognition as other older adults (e.g., Lindenberger, Kliegl, & Baltes, 1992), older experts seem to use their pragmatic knowledge of optimal performance strategies to ensure continued high level performance. Salthouse (1984), for example, found that older typists maintained comparable levels of typing proficiency as younger typists by compensating for reduced mechanical abilities (e.g., tapping speed) with advanced procedural skills (e.g., increasing the number of to-be-typed words in memory, presumably to reduce the number of attention shifts to the untyped copy).

The growth of domain-specific knowledge bases has positive implications for the worklife competence of older workers. As long as workers update and revise their knowledge bases to guard against obsolescence, workers with more on-the-job experience may be expected to have higher levels of job-relevant knowledge, and that knowledge may be more elaborated, complex, and tested by a broader range of potential problem situations. This topic will be considered in greater detail below. Table 2 (see Appendix A) illustrates a few of the pragmatic domains in which, for at least some highly experienced individuals, positive effects of aging have been documented. A number of these domains have been work-related; indeed, the structure and representation of the knowledge system has often been studied using the development of job-related expertise as a model.

- *Proposition 4: Many adults have a sizable reserve capacity, but there may be age-related limits on reserves.*

The reserve capacity idea reflects the concept that individuals can grow and change, and that they can acquire new knowledge and skills. In contrast to earlier times in the twentieth century, intellectual functioning is no longer seen as a given, unchangeable property of individuals; intelligence can be modified by social contexts and educational interventions (e.g., Lave & Wenger, 1991; Stanovich, 1991; Woodruff-Pak, 1989). Moreover, this modifiability has been documented throughout the life course, even in old age. Baltes, Willis, and colleagues (e.g., Baltes, Kliegl, & Dittmann-Kohli, 1988; Baltes & Lindenberger, 1988; Baltes, Sowarka, & Kliegl, 1989; Baltes & Willis, 1982; Bliesner, Willis, & Baltes, 1981; Hofland et al., 1981; Willis, 1987) have conducted a series of investigations designed to assess the modifiability, or plasticity, of older adults' intellectual performance. In general, they report that the simple provision of practice and/or training can lead to .5 to 1 standard deviation unit increases in scores. Training gains are task specific, but

long lasting, with trained subjects showing performance superiority over untrained controls for periods extending from six months to a year. Longitudinal fluid intelligence training research with older adults (e.g., Willis & Nesselroade, 1990; Willis & Schaie, 1986b, in press) has further demonstrated the potential remediating power and long-term protective effects of training and practice. Similar findings are reported in memory training research (Verhaeghen, Marcoen, & Goosens, 1992).

Despite the generally optimistic findings from training studies of memory and intelligence, there may be some age-associated losses in plasticity and performance potential. There is a systematic exploration of performance changes in the context of a theory-guided training program, which uses a research strategy called testing the limits (Kliegl & Baltes, 1987). Performance under supportive conditions (e.g., following practice and training, and in easy task conditions) is compared with performance in nonsupportive conditions (e.g., at fast speeds). In one set of studies (Baltes & Kliegl, 1992; Kliegl, Smith, & Baltes, 1989, 1990), both healthy younger and older adults were trained to use a mnemonic (Method of Loci) to serially recall a list of words. Instruction in the mnemonic substantially improved the memory performance of both younger (20-24) and older (60-75) adults of above-average intelligence; older adults went from a baseline recall of 5-7 words to a mean of about 15 words in correct order. There were limits, however, to how much the older subjects could improve their performance. Despite having acquired the Method of Loci, under high-challenge performance conditions of high speed, the lowest functioning members of the young group were typically still outperforming the highest functioning older adults. These findings suggest that plasticity in the cognitive mechanics of older adults cannot completely compensate for age-related restrictions in maximum performance potential under high-challenge conditions.

The cognitive intervention findings may have some positive implications for workplace and inservice education. The assumption that learning abilities wane in the course of adulthood is not unqualifiedly true. One can "teach an old dog new tricks," to borrow the cliché. Of course, findings from training in the cognitive mechanics are only somewhat relevant to the question of worker education involving information and procedural knowledge. At the same time, the finding that training gains can be achieved (a) by individuals who are older than many individuals in the workforce and (b) on abilities known to decline with age holds promise for the training potential of young and middle-aged workers on more practical, knowledge-based topics. Indeed, in the practical domain, older adults have been found to benefit from computer training (e.g., Charness, Schumann, & Boritz, 1992; Elias et al., 1987; Garfein, Schaie, & Willis, 1988; Hartley, Hartley, & Johnson, 1984; Zandri & Charness,

1989). On the one hand, this literature generally shows that older adults do require much longer that younger adults to learn to use new software (Charness & Bosman, 1990), and they make more errors. On the other hand, although the effort required to effectively train older adults may be greater than that needed with the young, older adults generally demonstrate positive performance gains in their use of software at the conclusion of training.

- *Proposition 5: During adulthood, there is often a shift in the areas in which intellectual functioning is applied. Domains of psychological functioning other than performance on intelligence tests may gain in importance.*
- *Proposition 6: Interindividual differences are likely to increase as a function of differences in life specializations and trajectories.*
- *Proposition 7: Some contexts, including work environments, may provide societally supported opportunities for high-level functioning and growth.*

These last three propositions highlight the important influence of context in understanding adult cognitive and intellectual competence, a notion that has already been suggested as central to life-span developmental psychology. This idea is considered in greater detail below, in the discussion of the contextual adaptedness of workplace competence. One implication is that one should not only consider the resources that adults bring to the workplace, but how the workplace itself can constitute a resource for adult workers. The mechanics-pragmatics distinction will now be focused upon, in order to address the extent to which performance on basic measures of intellectual functioning relates to on-the-job performance.

THE MECHANICS AND PRAGMATICS AT WORK

Having reviewed a basic framework for considering intellectual and cognitive abilities, and having presented findings regarding the adult development of such abilities, attention can now be turned to their application in workplace contexts. Specifically, the role of cognitive mechanics and pragmatics in work-related functioning is addressed. Much of this research has taken the form of correlational designs, in which indicators of intellectual and cognitive functioning have been related to selected job performance variables. It is important to note, however, that job performance is not an unambiguously measured construct. As is discussed in greater detail below, job performance is a multidimensional concept; different jobs are composed of many different tasks, and the importance of particular tasks may vary across individuals within the same nominal occupational category. Moreover, there are many ways to assess job performance: (a) self-ratings, (b) supervisor evaluations, (c) general impressions, and (d) behaviorally anchored rating scales. Performance can be assessed as process (How does

someone do their job?) or as outcome (How much money does an individual bring in? How many units of output does someone produce? What amount of impact and innovation do they generate?).

The continuing attempt to address issues of relevant job performance criteria in a theoretically meaningful and consistent way has a long history in industrial-organizational psychology (see Austin & Villanova, 1992) and cannot be addressed in detail here. It is conceptually important, however, to acknowledge that the relationship between job performance and mechanical or pragmatic cognitive abilities may vary as a function of both the cognitive abilities and job performance indicators assessed. Thus, a major point that we wish to bring to practitioners and policymakers interested in skills underlying workplace productivity and performance is that, in cognitive and personnel psychology, some of the most successful predictors of performance are not general skills and abilities, but specific competencies.

COGNITIVE MECHANICS AND JOB PERFORMANCE

A clear focus on the relationships between cognitive mechanics (e.g., speed, working memory capacity, attention, visuospatial ability) and job performance has really only emerged in recent years, as a consequence of the growing strength of information processing perspectives in cognitive psychology. Ability and aptitude measures account for relatively little variance in various job performance indicators—typically less than 20% (e.g., Sternberg & Wagner, 1993). On the other hand, intellectual ability is a fairly good predictor (about 50% of the variance) in work-related training outcomes (Ree & Earles, 1992) and in the accumulation of job-related knowledge (Schmidt & Hunter, 1992), an important finding that is considered more fully below.

An accumulating body of research suggests that the predictive salience of intellectual abilities, especially cognitive mechanics (e.g., speed, working memory capacity), changes over the worklife. In the industrial-organizational literature, this is discussed as the changing validities of predictor tests (e.g., Henry & Hulin, 1987, 1989; Jones, 1962). In longitudinal investigations of the relationship between various screening inventories and job performance, the usefulness of early screening measures for predicting job performance decreases as time goes on (Henry & Hulin, 1989). Ackerman (1989, 1992) has offered an intriguing model of why such predictive validities might decline; in his view, later job performance may be predicted by different abilities than earlier job performance. He suggested that learning a new perceptual-motor task requires general intellectual and problem-solving abilities (including the ability to detect relationships, to remember, etc.). With increased task-specific practice, individuals may automate aspects of the task. Eventually, individuals will reach an *asymptotic task performance level* (the point at which the task has been automated and no more improvements are observed); Ackerman predicts that at this point individual differences in performance will be best predicted by indicators of psychomotor speed.

Some job-related tasks at high levels of difficulty may be relatively more difficult to automate. Air traffic controllers, who need to continuously and rapidly scan dynamic visual displays, may only be able to automate general performance strategies. They must continually adapt, however, to the changing nature of the display. Other jobs with a high degree of task variety (i.e., jobs in which the same task may not be repeated very often) would also be less likely to

draw upon automated skills. Under these conditions, task performance may be more resource limited (e.g., Norman & Bobrow, 1975). Following from Ackerman's (1992) perspective, when task automation cannot be achieved, the predictive validities of the basic or general abilities may not change much over the worklife. In such jobs, general abilities and aptitudes may be constantly needed in order to adapt to continuous and changing challenges. Moreover, just as with cognitive training research findings, ability/performance relationships may be quite different in typical and maximal performance conditions. Under conditions of unexpected or high job pressure, automated task performance may be less helpful (e.g., Sackett, Zedeck, & Fogli, 1988).

The specificity of ability/job performance relationships has come to be an important underlying assumption in much of the current research attempting to specifically link the cognitive mechanics to job performance. There are several types of studies that have attempted to show the specificity relationship. In most cases, the focus has been visuospatial ability. One type of study examines whether members of particular occupational groups differ from members of other groups in terms of their specific intellectual abilities. For example, several research groups (Austin & Hanisch, 1990; Humphreys, Lubinski, & Yao, 1993; Lunneborg & Lunneborg, 1975) reported that when the occupational trajectories of individuals tested in high school were followed, students high on a spatial ability factor disproportionately tended to go into the physical science professions like engineering, mathematics, and computer science. High verbal individuals, on the other hand, disproportionately gravitated toward the humanities and social sciences.

Another approach to illustrating the specificity of the ability/job performance relationship involves attempts to explicitly predict job performance from individual differences in the cognitive mechanics. Gordon and Leighty (1988), for example, found that the likelihood of successfully completing a military aviation training course was positively predicted by level of visuospatial functioning. Ackerman and Kanfer (1993) reported that measures of complex spatial reasoning (Raven Progressive Matrices, Spatial Analogies) were among the best predictors of pilot performance on a flight simulator and an airplane. Overall, however, abilities accounted for only about 30% of the variance in performance, suggesting that even in a highly resource-demanding occupation, and when subjects are still early in their careers, much of the individual differences in job performance remain to be accounted for.

With regard to the aging of workplace functioning, two major domains of cognitive mechanics have been identified as important: losses in speed of responding (e.g., Salthouse, 1991) and increases in cautiousness or vigilance (e.g., Reese & Rodeheaver, 1985). Given the relatively low predictive salience of the cognitive mechanics in many studies of workplace functioning, one might expect that age-related losses in these abilities might not have a particularly strong effect on workplace functioning. Indeed, despite the existence of a strong negative stereotype regarding the aging of work-related skills (e.g., Stagner, 1985) a meta-analysis of a number of studies on the relationship between age and worker performance (McEvoy & Cascio, 1989) has reported that the relationship between age and job performance is effectively zero across most investigations. By implication,

age-related losses in the cognitive mechanics may not be particularly important for performance in many occupations. Exceptions may be professions that rely on very fast performance.

Although the evidence reviewed thus far has suggested that intellectual aptitudes and cognitive mechanics may be of limited usefulness in the prediction of workplace performance, this is not to suggest that they play no role. In the next section, it is suggested that job-related knowledge may be a very important predictor of individual differences in job performance. Recent psychometric research and theory (e.g., Hunter, 1986; Schmidt & Hunter, 1992; Schmidt, Hunter, Outerbridge, & Goff, 1988) have argued for an important indirect effect of intellectual ability on work performance (e.g., De Corte, 1993; Ostenk, 1992). The emphasis shifts away from what abilities people actually bring to the workplace and toward what their ability to change and grow in the workplace might be. Next, we will consider this ability to profit from workplace experiences in greater detail.

THE SPECIAL ROLE OF PRAGMATIC KNOWLEDGE: WORKPLACE EXPERTISE

There are some contexts and perspectives in which it may be important to consider the predictive salience of an individual's level of fluid intelligence and basic abilities in the workplace. Some other aspects of job performance appear to depend more on aspects of the pragmatics of intelligence, and to reflect the application, updating, and maintenance of technical knowledge and expertise in job-related domains. The domain of work encompasses a broad range of tasks involving different levels of cognitive (load) demand, technical knowledge requirements, interpersonal skills, support backup, and responsibilities. The major contribution of research in various domains of expertise (e.g., Chi & Glaser, 1988; Ericsson & Smith, 1991) has been to emphasize (a) the diversity of domain-specific knowledge (both factual and procedural), (b) sources of individual differences within domains in terms of knowledge acquisition and application, and (c) the necessity of examining the dialectics and dynamic interactions between individuals and their work environment over time. Basic skills and abilities of young adults assessed at or prior to entry to the workforce may well predict initial job performance (e.g., Ackerman, 1987); longer term progression and performance within an occupation or profession is, however, most likely related to aspects of the pragmatics of intelligence (e.g., knowledge and expertise acquired on the job).

Three central issues encountered in attempts to evaluate the predictive power of the knowledge-based pragmatics of intelligence in the workplace involve (a) the definition of job characteristics and demands, (b) the specification of performance (outcome) criteria, and (c) the development of assessment techniques. It is beyond the scope of the present report to review the literature related to these three issues; instead, a brief summary is provided to illustrate the extent of the problems faced by researchers (for more extensive reviews of various issues see Fried & Ferris, 1987; Kraiger, Ford, & Salas, 1993; Roberts & Glick, 1981; Tuijnman & Van Der Kamp, 1992).

First, we will consider the general definition of job characteristics and demands. Here, discussion focuses on the applicability of models devised in the 1970s that described jobs in terms of five core dimensions: (a) skill variety, (b) task identity, (c) task significance, (d) autonomy, and (d) feedback from the job

itself. Jackson, Wall, Martin, and Davids (1993) have summarized subsequent efforts to update these dimensions. Their proposals about additional constructs serve to illustrate the immense task of both trying to derive general models and linking those models to concepts of basic skills and the pragmatics of intelligence. Jackson et al., for example, suggest five additional dimensions: (a) timing control (extent of self vs. external regulation and scheduling of work behavior), (b) method control (extent of individual choice), (c) monitoring demand (passive vs. active prevention of or recovery from errors), (d) problem-solving demand (e.g., knowledge application vs. innovation), and (e) production responsibility (the cost of errors in terms of lost output and equipment damage). There are, no doubt, other dimensions that might be added. One important additional dimension might be the demands for social and interpersonal skills. For example, when considering the requirements and opportunities for team versus individual performance and the extent to which cognitive activity is expected to be carried out alone or in collaboration with others, individuals' abilities to work with others must be taken into account.

What performance or outcome variables are relevant to assessing the predictive power of the knowledge-based pragmatics of intelligence in the workplace and how might these be measured? In the section above, criteria such as speed, accuracy, and learning capacity, which primarily tap the relevance of the mechanics of intelligence for job performance, were discussed. Here, the focus shifts to the more knowledge- and experience-based aspects of intellectual capacity: These aspects are especially thought to predict the maintenance and progression of job performance over time (i.e., throughout the individual's history in a particular job or career).

Are there particular aspects of knowledge and domain expertise that are important for job performance? Many lists of specific criteria could be devised, but with regard to general outcomes, there is consensus in the literature that the following constructs are central to describing an individual's level of expertise and to distinguishing performance quality: (a) amount of knowledge (including verbal knowledge about declarative or technical details, procedural and strategic knowledge, and practical knowledge); (b) level and nature of knowledge organization (as this relates to the representation of problems, information access, and storage); and (c) metacognitive strategies (including tacit knowledge about managing oneself and others, insight into one's own capabilities and limits, and application of this insight to on-the-job performance).

Assessment of these knowledge- and experience-related performance criteria (i.e., amount and organization of knowledge, meta-strategies) and specification of different levels of expertise is not an easy task. Measures of accuracy in relation to amount of knowledge or speed in relation to knowledge organization do not provide sufficient information for understanding performance. In many cases, domain-specific technical knowledge is highly complex and application of this knowledge can involve the implicit estimation of many unknowns and uncertainties. When devising a test for such specific and complex domains, it might be possible to identify a prerequisite set of facts and procedures that individuals should recognize or recall in relation to a particular problem scenario. It is not always possible, however, to specify one correct solution to these problem scenarios. In many domains, greater knowledge involves knowing about many alternative

answers and having strategies for selecting among these alternatives in order to find a context-specific best match (e.g., Dowie & Elstein, 1988; Wagner & Sternberg, 1986). It is precisely this feature of the pragmatics of intelligence that often calls for the development of assessment strategies other than formal pen-and-pencil tests.

A frequently employed alternative to the formal test method of assessing job-related knowledge and performance is to utilize ratings provided from sources inside the workplace (e.g., supervisors, trainers, fellow workers) or outside of it (e.g., external consultants, collaborating companies, public relations surveys). While highly valuable and informative, such ratings may also be biased. The rater's own level of competence, perception of job requirements and demands, personal values, and motives in relation to the ratee, may influence their evaluation (Yammarino & Waldman, 1993). For many tasks and domains, however, these biases can be made visible (and can become a topic of investigation in their own right) by employing not one but several raters. Overall rater consensus or selected rater-by-dimension indicators can then be used as measures of performance. Additional assessment measures and procedures (albeit usually analysis intensive) are discussed in cognitive science research when describing differences between novices and experts within specific domains. Another special feature of this literature (which also serves to refer to the issue raised above concerning definition of job characteristics and demands) is an emphasis on the necessity of careful specification of the nature of the task in relation to understanding and assessing expert performance (Ericsson & Smith, 1991).

STUDYING AND EVALUATING EXPERTISE

The concept of expertise and various theories about the nature and acquisition of expert knowledge provide a useful framework for formulating hypotheses about developmental changes within a particular job or professional career (e.g., expected amount and organization of knowledge and metacognitive strategies) and for examining the consequences of these changes for job performance. Generally, the term *expertise* is associated with the long-term accumulation of an extensive, highly organized and integrated factual and procedural knowledge base and with high-level performance (Chi & Glaser, 1988; Ericsson & Smith, 1991). In the course of adult activities (related not only to work, but also to family, leisure, interpersonal contexts, and idiosyncratic interests) and by virtue of living longer, individuals have the opportunity to accumulate knowledge in a variety of domains. The extent to which these opportunities are realized will vary between individuals. Only some individuals, by virtue of their particular life ecology or their self-motivated concentration and specialization in one (or more) domain, may develop areas of expertise and reach the status of a recognized expert in a domain.

The research paradigm associated with the study of expertise and expert knowledge involves attempts to determine how differences in the amount and organization of knowledge in a domain contribute to observed performance differences between experts and novices (Glaser, 1984). It is somewhat trivial to show that complete novices (i.e., individuals with zero or minimal knowledge) perform very poorly in a domain compared to those who have some knowledge. Instead, researchers have focused on comparisons between the performance of seminovices and established experts: for example, early versus later performance in a training program (e.g., undergraduate vs.

graduate computer programmers) or performance at different phases in a career path (e.g., physics graduates vs. physics professors). These latter comparisons suggest that, over and above possession of a certain amount of knowledge and practice, the nature of knowledge organization becomes of greater importance in predicting performance. Precisely how this organizational transformation arises is unknown (see Wagner & Scurrah, 1971). The finding, however, matches naive observations that newcomers to a job, even if their training grades are exceptionally high, still have much to learn to reach the level of someone with more on-the-job experience.

The effects of differences in knowledge organization might be evident at many phases of performance on a task, such as initial problem representation, information search, information access, and analogy generation. A central finding has been that, among other things, experts and novices often differ at the initial stages of the problem-solving process, and especially in their representation (or understanding) of the problem (e.g., Chi, Glaser, & Rees, 1982). As Glaser explained, "the knowledge of novices is organized around the literal objects explicitly given in a problem statement. Experts' knowledge, on the other hand, is organized around principles and abstractions that subsume these objects" (p. 98). Evidence in support of this is particularly strong in job tasks that require some sort of initial diagnostic analysis, and where the results of this analysis have important implications for guiding subsequent behavior. Such occupations include (a) car mechanics, (b) office and warehouse workers in a dairy business (Scribner, 1986), (c) academics and business managers (Wagner & Sternberg, 1986), (d) medical doctors, clinical psychologists, and investment advisors (Dowie & Elstein, 1988; Goldberg, 1986), and (e) parole officers and judges (Carroll, 1986).

In part, knowledge organization differences may also reflect the operation of metacognitive strategies, another central feature of the pragmatics of intelligence. Compared to novices, experts are more likely to discontinue an unsuccessful problem-solving strategy, to be more accurate in judging the difficulty of new problems and tasks, and better able to estimate the amount of time and effort needed to complete a task (Chi et al., 1982). Wagner and Sternberg (1986) have also reported differences between experts and novices in tacit knowledge about managing oneself, others, and tasks. They found that the relationship between tacit knowledge and criterion measures of career performance (e.g., productivity, recognition) is much stronger than that between assessments of IQ or employment entry tests and job performance.

The adept use of metacognitive knowledge acquired through years of experience is a feature of adult functioning that, although studied in cognitive science experimental settings, has received relatively little attention in the literature on work performance. Traditional tests of basic skills assess very little of this type of knowledge, and yet it is precisely this knowledge that may relate to and predict the maintenance and upgrading of job performance from early through to late adulthood.

Apart from outlining central differences between novices and experts, the literature on expertise also highlights the important role of continued practice, challenge, and updating of knowledge for the maintenance of expert performance. The work environment offers many different opportunities to apply the skills and knowledge acquired during adolescence and early

adulthood, to specialize and extend these skills and to acquire new skills. In some occupations, these opportunities are institutionalized, for example, as part of the structural organization of a career ladder and continuing-education programs. In other occupations, there is less structural support for continued development.

Especially in fields that require adaptation to new technologies, participation in continuing-education programs counts as one of the best predictors of maintenance of job performance during the work career, moderating the adverse effects of age. Sparrow and Davies (1988), for example, found that age accounted for very little of the explained variance in job performance (speed, quality) of engineers aged 26-35 years, 36-44 years, and 46-55 years. Rather, recent participation in training was a significant moderator. They also noted that it was the particular type of recent training that was critical: the 36-44 and 46-55 year-olds benefited most from programs tailored to their specific group and career-level needs in the workplace.

Work-related training that is not tailored to the needs and capacities of the trainees may be less effective in moderating the maintenance and updating of expertise. Indeed, within organizations, training opportunities are often only made available to young employees on the assumption that the cost of provision to middle-aged and older workers would not be recovered in subsequent performance. In this regard, it is important, once again, to refer to the set of propositions that were outlined in the beginning of this report, and to emphasize that training at all ages is beneficial in that it can afford both maintenance and growth. Two studies will be described in some detail here to illustrate the complex level of thinking and problem-solving performance that can be demonstrated by middle-aged and older adults who invest time and effort in training and practice. The training in this case was self-initiated, and the tasks were associated with leisure interests. The first study deals with chess players (Charness, 1981) and the second with horse race handicappers (Ceci & Liker, 1986).

Charness devised several memory and problem-solving tasks to evaluate whether aging influenced the processing strategies of competition chess players. His subjects ranged from 16 to 64 years of age, and at each age level individuals were selected from various skill levels. On average, these people played chess for 6 hours a week. The problem-solving tasks involved thinking aloud about selecting a move in a specific game with and without time pressures. Charness found that the more skilled the players, the longer it took them to choose a move. Older skilled players, however, took a shorter time and selected better moves. Furthermore, older skilled chess players were not disadvantaged by a time pressure. Clearly, these older adults, functioning in a domain in which they were highly experienced, were not inferior to young adults with similar levels of chess skill.

Ceci and Liker (1986) demonstrated that performance on the Wechsler Adult Intelligence Scale (WAIS) was unrelated to the highly sophisticated and complex reasoning shown by men who were expert in race handicapping. The men were regular race attenders with track experiences ranging from 7 to 23 years. They all maintained other occupations. Non-expert handicappers, classified by their success in predicting race winners, had similar amounts of track experience. Unfortunately, Ceci and Liker did not note their subjects' ages. It is reasonable to assume, however, that they were middle aged. Experts,

regardless of their IQ levels, were found to consistently use a reasoning model involving multiple interactions between at least seven variables on a simulation task that required 2-horse comparisons. Ceci and Liker pointed out that in real-life situations, where races are between 8 to 10 horses, many additional variables would be successfully added to this model. Surprisingly, subjects' scores on the Arithmetic subtest of the WAIS were found to be unrelated to the reasoning feats demonstrated on the simulation task.

The race handicappers, like the chess players studied by Charness, had developed highly complex thinking and problem-solving skills in the course of their adult lives. Similar, highly complex knowledge bases and strategies can be developed for work domains and represent the category of cognitive functioning associated with the pragmatics of intelligence.

CONCLUSIONS: BASIC SKILLS, INTELLIGENCE, AND WORKPLACE PERFORMANCE

How is one to reconcile the ideas in this report about the mechanics and pragmatics of intelligence and their relationship to workplace performance with notions of basic skills? Basic skills are really complex composites of intellectual and cognitive abilities as they have been invested in accultured and educationally directed outcomes. In this sense, it may be more appropriate to call them complex domain-general skills. Like intelligence, with which literacy and numeracy are highly correlated, basic skills represent capacity to learn or general resources for learning. Emerging perspectives in literacy research (e.g., Hull, 1993; Resnick, 1990), industrial-organizational psychology (e.g., Ackerman & Kanfer, 1993), and life-span developmental psychology (e.g., Baltes, 1993; Lerner, 1984) all converge in asking (a) how these skills are applied for learning in relevant domains, (b) how they are extended and maintained through adulthood, and (c) how they are transformed into individual differences in specialized tasks.

The following are some conclusions and recommendations generated by our study.

- *Workplaces supplant schools as the major locus of adult learning.* Consequently, more attention must be paid to the kinds of formal and informal learning opportunities that occupational settings provide. What kinds of organizational contexts are most facilitative of adult learning? What kinds of training programs are most effective?
- *Intellectual and literacy functioning are closely allied.* An exclusive focus on literacy skills ignores the potential contributions that other research on adult cognition and intelligence can make. There is a need for more integration between these disparate research areas. Adult education specialists interested in workplace productivity need to

explain why they prefer the literacy concept to the intelligence concept. Specifically, while traditional psychometric measures of intellectual functioning, as well as more state of the art measures of cognitive processing, also represent complex admixtures of cognitive potential and culturally transmitted knowledge, they at least have the virtue of being at a lower level of aggregation than basic skills.

- *More longitudinal research is needed.* Researchers should increasingly study the course of basic skills through adulthood. How and why do literacy levels change? Are literacy skills differentially related to occupational productivity across the work career?
- *There is a need for increased blending of macro- and micro-approaches.* General surveys of general skills, it has been argued, capture only a part of the literacy story. How do specific contexts influence literacy? Are specific, nongeneral skills needed in those contexts? Such domain-specific questions can be addressed in a number of ways. Different work contexts (e.g., certain factory types, certain vocations) can be sampled. Domain-general questionnaires can be given across contexts at the same time as domain-specific questionnaires are given within contexts. Alternatively, research drawing on the expertise approach can carefully study the domain-specific occupational skills of participants who also take general literacy and ability surveys.
- *In developing predictors of job performance, it is probably not useful to think of a single class of predictors, measured once.* Individual standings on measures of cognitive functioning change over time. There are general developmental changes as well as individual differences in the amount of engagement with stimulating environments. Thus, the relationship between aptitude, achievement, and ability measures and indicators of job performance varies over time. Different abilities should predict complex task performance throughout the work career. Furthermore, methodologists have increasingly come to question the utility of single assessments of any construct (e.g., Nesselroade, 1991). Taken together, the research suggests that single administrations of screening inventories early in the work career will have very limited utility for understanding performance throughout the worklife.
- *The relationship between literacy and economic productivity may extend beyond the workplace.* Cognitive skills are not needed just for job performance. What are the costs to society of low skills and competencies in younger and older adults who cannot read medicine labels, bus schedules, or insurance applications? The nonoccupational economic implications of literacy skills need to be further considered.

In summary, contextual models of job performance may be more helpful. It is important to note that contextual models are prevalent in the expertise literature (e.g., Ericsson & Smith, 1991), but they have relatively less

endorsement in mainstream industrial/organizational research. The hallmark of the expertise approach to studying work performance is job and task analysis. The selection of predictors will need to vary with the job type. Some jobs, for example, may impose high attentional or memory demands on individuals (e.g., the air traffic controller). Other professions may place a premium on speed of performance (e.g., the supermarket checker or the assembly line worker). Still others, however, may rely more on one's reservoir of task specific knowledge. It does not seem reasonable to assume that the same class of predictors will function usefully for understanding performance in all of these work categories.

Broad, domain-general abilities must be supplemented as predictors by narrow measures of task-specific knowledge. This poses the measurement challenge for differential psychology, however, since good measures of domain-specific knowledge generally do not exist (e.g., Willis & Schaie, 1993). It also poses a challenge because of psychology's tradition of assessing broad, domain-general constructs in the search of nomothetic theories. The kinds of knowledge needed in different professions will vary, both in content and in organizational structure. Moreover, professions will vary in the extent to which knowledge needs updating. In highly technical professions under conditions of rapid technological advance, for example, knowledge needs to be constantly revised. In order to understand individual differences in performance in such high-knowledge domains, not only must knowledge be assessed, but (congruent with our dynamic conception) it must be constantly reassessed, and the content assessed must change over time.

There is a need to consider the noncognitive dimensions of workplace functioning. In the present treatment, noncognitive dimensions have not been emphasized, since they go beyond the scope of the present report. In the literature, dimensions of motivation (especially achievement motivation and intrinsic task motivation) have been studied most heavily, and more complex models of the noncognitive predictors of occupational competence have received less attention. How does one's identity as a worker fit into the broader scheme of one's multiple selves (e.g., Markus & Herzog, 1991)? How might one's investment in the role of worker change over the occupational life course (e.g., Brim, 1992)? How might one adjust one's aspirational levels in the workplace as one's perceptions of competence vary, and how does aspirational level relate to job performance (e.g., Heckhausen & Schulz, 1993)? To what extent are personality dimensions like openness to experience (e.g., Costa & McCrae, 1980) or flexibility (e.g., Schaie, Dutta, & Willis, 1991) important for understanding both job performance and the ability to profit from experience? These questions are mentioned only to suggest that good models of workplace competence will ultimately need to go beyond simple conceptions of cognitive and intellectual skills.

In conclusion, it has been argued that the basic skills assessment approach is limited in its usefulness for explaining individual differences in performance on the job. An alternative framework was offered that deals with the mechanics and pragmatics of intelligence. It was argued that this framework provides a better separation of the domain-general and domain-specific competencies that individuals need in the workplace. In the long run,

concepts associated with this framework, especially contextualism, life-span opportunities for development, and the proposal that development is multidimensional and multidirectional may be more useful than basic skills conceptions in trying to understand effective functioning on the job.

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APPENDIX

Table 1 *The Mechanics of Intelligence: Cognitive Processes That Show Age-Associated Losses* *A-iii*

Table 2 *The Pragmatics of Intelligence: Knowledge-Based Functioning Can Grow With Age* *A-iv*

Figure 1 *Cattell and Horn's Theory of Intelligence* *A-v*

Table 1

The Mechanics of Intelligence: Cognitive Processes That Show Age-Associated Losses

Functional category	Major reviews
Visual search	Plude & Hoyer (1985)
Attentional capacity	Hartley (1992)
	Hasher & Zacks (1988)
	McDowd & Birren (1990)
Speed	Salthouse (1991)
Primary & working memory	Craik & Jennings (1992)
	Poon (1985)
	Craik (1983)
	Salthouse (1991)
	Craik, Morris, & Gick (1990)
Reasoning & spatial ability	Salthouse (1992)
	Horn & Hofer (1992)
	Schaie (in press)

Table 2

The Pragmatics of Intelligence: Knowledge-Based Functioning Can Grow With Age

Functional category	Major reviews
Semantic organization & conceptual knowledge	Light (1992)
Wisdom	Baltes, Smith, & Staudinger (1992)
	Smith & Baltes (1990)
	Sternberg (1990)
Everyday knowledge	Cornelius & Caspi (1987)
	Sinnott (1989)
Verbal ability	Horn & Hofer (1992)
	Schaie (in press)
Job- & leisure-related expertise	Ericsson & Smith (1991)
	Charness (1985)
	Salthouse (1990)
	Simonton (1990)
	Birren (1969)
	Bromley (1969)
	Chi & Glaser (1988)

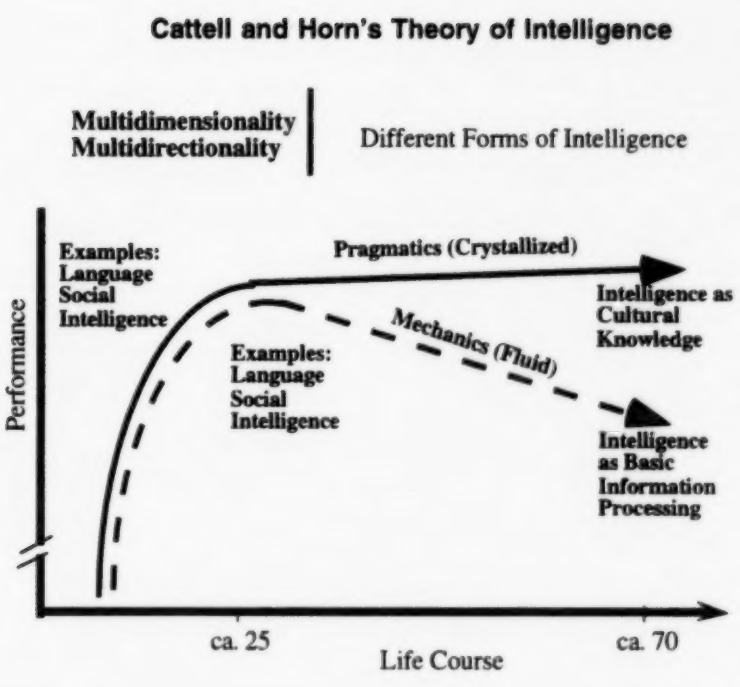

Figure 1. **One of the best known psychometric structural theories of intelligence is that of Cattell and Horn. The two main dimensions of that theory, fluid and crystallized intelligence, are postulated to display different life-span developmental trajectories (adapted from Baltes, 1987).**